HOMOGENIZATION OF CELLULAR SOLIDS

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In the last decade new manufacturing processes have quickly emerged, giving rise to new promising multifunctional material systems, composite or cellular based, with various applications. Proper understanding of their mechanical and other properties requires solid knowledge of micromechanics.
This seminar will start by reviewing the concept of effective elastic properties. Homogenization procedures, either based on asymptotic expansion approaches or on averaging techniques will be quickly reviewed. Periodic versus random media, basic cell versus representative volume element and their boundary conditions will be illustrated. Voigt, Reuss and Hashin-Shtrikman bounds on limit elastic properties will be summarized.
A general approach allowing explicit analytical description of effective properties of cellular solids with periodic microstructure is presented. The approach does not require any kind of particular microstructure symmetry.
A methodology to derive the linear effective constitutive law of group of composites with random microstructure of special kind is described as extension of the methodology used in polycrystalline aggregates. The results are expressed in form of specific bounds on effective elastic constants. The bounds have a practical importance when the group of composites is specified to cellular solids.
A methodology to determine upper bounds on homogenized linear elastic properties of open-cell cellular solids is presented. Besides the upper bounds the methodology provides necessary and sufficient conditions on the optimal media. These conditions are written in terms of generalized internal forces and geometrical parameters. In some cases dependence on internal forces can be replaced by geometrical expressions. In such cases optimality of some medium under consideration can be verified directly from the microstructure, without any additional calculation.
Another practical application of Reuss and Hashin-Shtrikman lower bounds is related to vibration mitigation. These bounds can be re-written for viscoelastic materials with complex moduli and then the optimal media, i.e. the ones saturating the bounds provide optimal damping properties. Usage of quasi-zero stiffness materials within this context is exemplified.

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